INDOOR AIR QUALITY ASSESSMENT

Gardner Middle School
297 Catherine Street
Gardner, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
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Background/Introduction

At the request of Michael Sireci of the Massachusetts Teachers Association (MTA), the Bureau of Environmental Health Assessment (BEHA) was asked to provide assistance and consultation regarding indoor air quality issues and health concerns at the Gardner Middle School, 297 Catherine Street, Gardner, Massachusetts.

On June 23, 2003, a visit was made to this school by Michael Feeney, Director of Emergency Response/Indoor Air Quality (ER/IAQ), BEHA, to conduct an indoor air quality assessment. Mr. Feeney was accompanied by Bernard F. Sullivan, Health Director, Gardner Health Department; Daniel Costello, Principal, Gardner Middle School; other Gardner Public School (GPS) personnel and Mr. Sireci. Reports of an individual with concerns related to mold and indoor air quality prompted this request.

The school is a multi-level brick building originally constructed in 1997. The upper levels of the school contain general classrooms and the library. The lower level consists of the gymnasium, cafeteria, teachers' lunchroom, administrative offices, nurse's office and conference rooms. Windows open in classrooms.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551. Water content of carpet was measured with Delmhorst, BD-2000 Model, Moisture Detector with a Delmhorst Standard Probe.

Results

The school houses middle school students in grades 6-8. It has a student population of approximately 700 and a staff of over 50. Tests were taken during normal operations at the school and results appear in Table 1.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 parts per million parts of air (ppm) in twelve of eighteen occupied areas surveyed (thirty three total areas were sampled), indicating a ventilation problem in the majority of areas tested at the school. Note that three areas, cafeteria, C108 and C104, had increased occupancy due to end of the year activities. A number of classrooms (Table 1) were sparsely occupied during this assessment due to end of the year activities. With increased occupancy, carbon dioxide levels in classrooms would be expected to be higher

Fresh air in classrooms throughout the building is provided by unit ventilators (univents) (Figure 1, Picture 1). Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building and return air through an air intake located at the base of each unit. The mixture of fresh and return air is drawn through a filter and heating coil and is then provided to the classroom from the univent by motorized fans through a fresh air diffuser on the top of the unit. Univents were operating in all areas surveyed; however, a number of units were obstructed. One univent had its return vent blocked with wood planks (Picture 2). To function as designed, univent diffusers and returns must remain free of obstructions.

The mechanical exhaust ventilation system consists of wall-mounted exhaust vents. These vents were operating throughout the building. The location of some exhaust vents can limit exhaust efficiency. When a classroom door is open, exhaust vents will tend to draw air from both the hallway and the classroom. The open hallway door reduces the effectiveness of the exhaust vent to remove common environmental pollutants from classrooms.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last balancing of these systems was reportedly conducted upon completion of construction in 1997. GPS officials report plans to rebalance the ventilation system during the 2003 summer break. It is recommended that HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, consult Appendix I.

Temperature measurements ranged from 75° F to 78° F, which were within the BEHA recommended comfort range in all areas. The BEHA recommends that indoor air temperatures be maintained in a range of 70° F to 78° F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity measured in the building ranged from 47 to 65 percent, which was within or slightly outside of the BEHA recommended comfort range. The

BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Of note is the indoor relative humidity measured in a number of areas, which exceeded outdoor measurements by 2-10 percent. The increase in relative humidity can indicate that the exhaust system is not operating sufficiently to remove normal indoor air pollutants (e.g., water vapor from respiration). Moisture removal is important since the sensation of heat will increase as relative humidity rises. This relationship is commonly referred to as the heat index. If moisture level is lowered, the discomfort of the individuals is decreased.

While temperature is mainly a comfort issue, relative humidity in excess of 70 percent can provide an environment for mold and fungal growth (ASHRAE, 1989). During periods of high relative humidity, windows and exterior doors should be closed to keep moisture out; in addition, AHUs, univents and exhaust ventilation should be activated to control moist air in the building.

Microbial/Moisture Concerns

As indicated by school personnel, the teachers' room has been a source of concern due to the sloping of the sidewalk outside this area towards the building (Picture 3). An examination of the perimeter revealed large gaps in the sidewalk/exterior wall junction, which allows for accumulation of rainwater (Picture 4). Water penetration through an exterior door was noted in the doorframe (Picture 5). The teachers' lunchroom floor is covered with wall-to-wall carpeting. The carpeting installed to the door threshold and doorframe showed signs of water damage (Picture 5). Moisture samples were taken from the carpeting. Most areas of carpeting had detectable levels of moisture, indicated that the carpet near the exterior wall was saturated. GPS staff planned to remove the carpet and install tile after moistened carpeting was found in the teachers' lunchroom. According to Paul Schaeffer, GPS, no accumulated water was found underneath the carpet along exterior walls (personal communication, Schaeffer, 2003).

GMS does not have an air conditioning ventilation system, therefore, the indoor relative humidity will be dictated by outdoor relative humidity concentrations. For example, during the spring and summer of 2002, New England experienced a stretch of excessively humid weather during three periods in May, July and August. Specifically, outdoor relative humidity at various times ranged from 73 percent to 100 percent without precipitation from July 4, 2002 through July 12, 2002 (The Weather Underground, 2003).

According to the American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE), if relative humidity exceeds 70 percent, mold growth may occur due to wetting of building materials (ASHRAE, 1989). High relative humidity can cause the accumulation of moisture on surfaces that have a temperature lower than the ambient air temperature (e.g., building surfaces in contact with soil such as foundation floor or cement slabs). If the floor of teachers' lunchroom is prone to moisture accumulation, carpeting should not be used as a floor covering. The American Conference of Governmental Industrial Hygienists (ACGIH) recommends that carpeting be dried with fans and heating within 24 hours of becoming wet (ACGIH, 1989). If carpets are not dried within this time frame, mold growth may occur. Water-damaged carpeting cannot be adequately cleaned to remove mold growth. The application of a mildewcide to moldy carpeting is not recommended.

Exterior wall systems should be designed to prevent moisture penetration into the building interior. An exterior wall system should consist of an exterior curtain wall (Figure 2). Behind the curtain wall is an air space that allows for water to drain downward and for the exterior cladding system to dry. At the base of the curtain wall should be weep holes that allow for water drainage. Opposite the exterior wall and across the air space is a continuous, water-resistant material adhered to the back up wall that forms the drainage plane.

The purpose of the drainage plane is to prevent moisture that crosses the air space from penetrating into interior building systems. The plane also directs moisture downwards toward the weep holes. The drainage plane can consist of a number of water-resistant materials, such as tarpaper or, in newer buildings, plastic wraps. The drainage plane should be continuous. Where breaks exist in the drainage plane (e.g., window systems, door systems and univent fresh air intakes), additional materials (e.g. copper flashing) are installed as transitional surfaces to direct water to weep holes. If the drainage plane is discontinuous, missing flashing or lacking air space, rainwater may accumulate inside the wall cavity and lead to moisture penetration into the building.

In order to allow for water to drain from the exterior brick wall system, a series of weep holes is customarily installed at or near the foundation slab/exterior wall system junction (Figure 2). Weep holes allow for accumulated water to drain from a wall system (Dalzell, 1955). Failure to install weep holes in brickwork or burial of weep holes below grade will allow water to accumulate in the base of walls, resulting in seepage and possible moistening of building components (Figure 3).

The exterior of the GMS consists of a traditional red brick exterior wall (Picture 6). An examination of the exterior brick walls of GMS was conducted to identify the location and condition of weep holes. Weep holes were found above grade on the west, north and east facing exterior walls (Picture 7). Weep holes in these walls were open. In contrast, the south exterior wall of GMS did not have identifiable weep holes. Since the south wall is of similar design to the rest of the building, weep holes in this section may be buried by accumulated loam, dirt or cedar flakes along the edge of these walls. It is advised that "[i]n no case should the holes be located below grade", since dirt can fill weep holes to prevent drainage (Dalzell, 1955).

Furthermore, several areas also have a number of plants. Plant soil, standing water and drip pans can be potential sources of mold growth. Drip pans should be inspected periodically for mold growth and over watering should be avoided.

Other Concerns

A number of other conditions that can potentially affect indoor air quality were also observed. In an effort to reduce noise from sliding chairs and tables, tennis balls were sliced open and placed on chair legs. Tennis balls are made of a number of materials that are a source of respiratory irritants. Constant wearing of tennis balls can produce fibers and off-gas VOCs. Tennis balls are made with a natural rubber latex bladder, which becomes abraded when used as a chair leg pad. Use of tennis balls in this manner may introduce latex dust into the school environment. Some individuals are highly allergic to latex (e.g. spina bifida patients) (SBAA, 2001). It is recommended that the use of materials containing latex be limited in buildings to reduce the likelihood of symptoms in sensitive individuals (NIOSH, 1997). A question and answer sheet concerning latex allergy is attached as Appendix II (NIOSH, 1998).

Located in the seventh floor teacher's room are a number of duplicating machines. No dedicated local exhaust ventilation for the photocopiers exists, however, exhaust ventilation is provided by restroom exhaust vents. In order to provide sufficient air for exhaust vents to draw air, it is the usual practice to undercut restroom doors to create a one-inch minimum space. Restroom doors were not undercut, preventing the draw of air from the teachers' room. Without draw of air, pollutants generated by duplicating equipment will accumulate in the teachers' room as these machines operate. Of note is that at least one printer, the Risograph®, uses a liquid toner. Photocopiers can produce volatile organic compounds (VOCs) and ozone, particularly if the equipment is older and in frequent use. VOCs and ozone are respiratory irritants (Schmidt Etkin, 1992). It is recommended that local separate exhaust systems that do not recirculate into the general ventilation system be used.

Of note is the use of individually purchased cleaning materials in the building. Cleaning materials frequently contain ammonium compounds or sodium hypochlorite (bleach-products), which are alkaline materials. The use of these products can provide exposure opportunities for individuals to a number of chemicals, which can lead to irritation of the eyes, nose or respiratory tract. In all of these instances, cleaning products containing respiratory and skin irritants appear to be used throughout the building.

Conclusions/Recommendations

BEHA staff attempted to identify possible environmental sources that have could be potential mold growth/allergen/respiratory irritant sources. Several possible sources influencing indoor air quality (e.g., teachers' lunch room carpet, latex dust source, impaired exhaust ventilation in the teachers' room with duplicating equipment) were also identified. If the individual continues to reports symptoms related to indoor air quality after completion of the recommendations within this report, then consultation with an environmental/occupational physician may be considered.

In view of the findings at the time of our inspection, the following recommendations are made to improve general indoor air quality:

1. Continue with plans to balance the ventilation system during the 2003 summer break.
2. Remove all obstructions from univent air diffusers and return vents to facilitate airflow.
3. Determine if weep holes exist in the south wall of GMS. Unearth all weep holes in exterior walls to maximize water drainage from exterior wall systems.
4. Encourage faculty and staff to report any complaints concerning temperature control/preventive maintenance issues to the facilities department in the form of a work order. These work orders are reportedly provided by the school maintenance staff and/or administration.
5. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can

be enhanced when the relative humidity is low. To control for dusts, a HEPA filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

6. Consider reducing the number of plants and moving them away from univents. Avoid over-watering and examine drip pans periodically for mold growth. Disinfect with an appropriate antimicrobial where necessary.

7. Undercut restroom door in all teachers' room by a minimum of one inch to provide adequate transfer air for restroom and exhaust ventilation for teachers' rooms. Consider moving the Risograph® close the restroom doors to provide maximum exhaust ventilation. Examine the feasibility of providing local exhaust ventilation for duplicating equipment in teachers' rooms or relocate equipment to an area with adequate exhaust ventilation.

8. Reduce the use of cleaning materials that contain respiratory irritants (ammonia related compounds) on floors and in classrooms. Do not use these materials to disinfect equipment that comes into close human contact (e.g., telephones). Substitute plain soap and hot water for ammonia related cleaning products. Cleaning products that contain ammonia should only be used where necessary. If ammonia containing cleaning products is used, rinse the area of application with water to remove residue.

9. Consider discontinuing the use of tennis balls on chairs to prevent latex dust generation.

10. Replace water damaged ceiling tiles.

11. Slope sidewalk away from teachers' lunchroom. Seal sidewalk/exterior wall junction with an appropriate sealing compound.
12. Continue with plans to remove carpet from teachers' lunchroom and replace with tile.
13. Consider adopting the US EPA document, "Tools for Schools" (US EPA, 1992) as recommended by the Athol Board of Health as a means to maintaining a good indoor air quality environment in the building. This document can be downloaded from the Internet at http://www.epa.gov/iaq/schools/index.html.
14. For further building-wide evaluations and advice on maintaining public buildings, refer to the resource manual and other related indoor air quality documents located on the MDPH's website at http://www.state.ma.us/dph/beha/iaq/iaqhome.htm.

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http://www.wunderground.com/history/airport/KFIT/2002/7/8/DailyHistory.html
http://www.wunderground.com/history/airport/KFIT/2002/7/9/DailyHistory.html

Figure 2
The Function of the Drainage Plane and Weep Holes to Drain Water from the Wall System, Prevent Moisture Penetration into the Interior

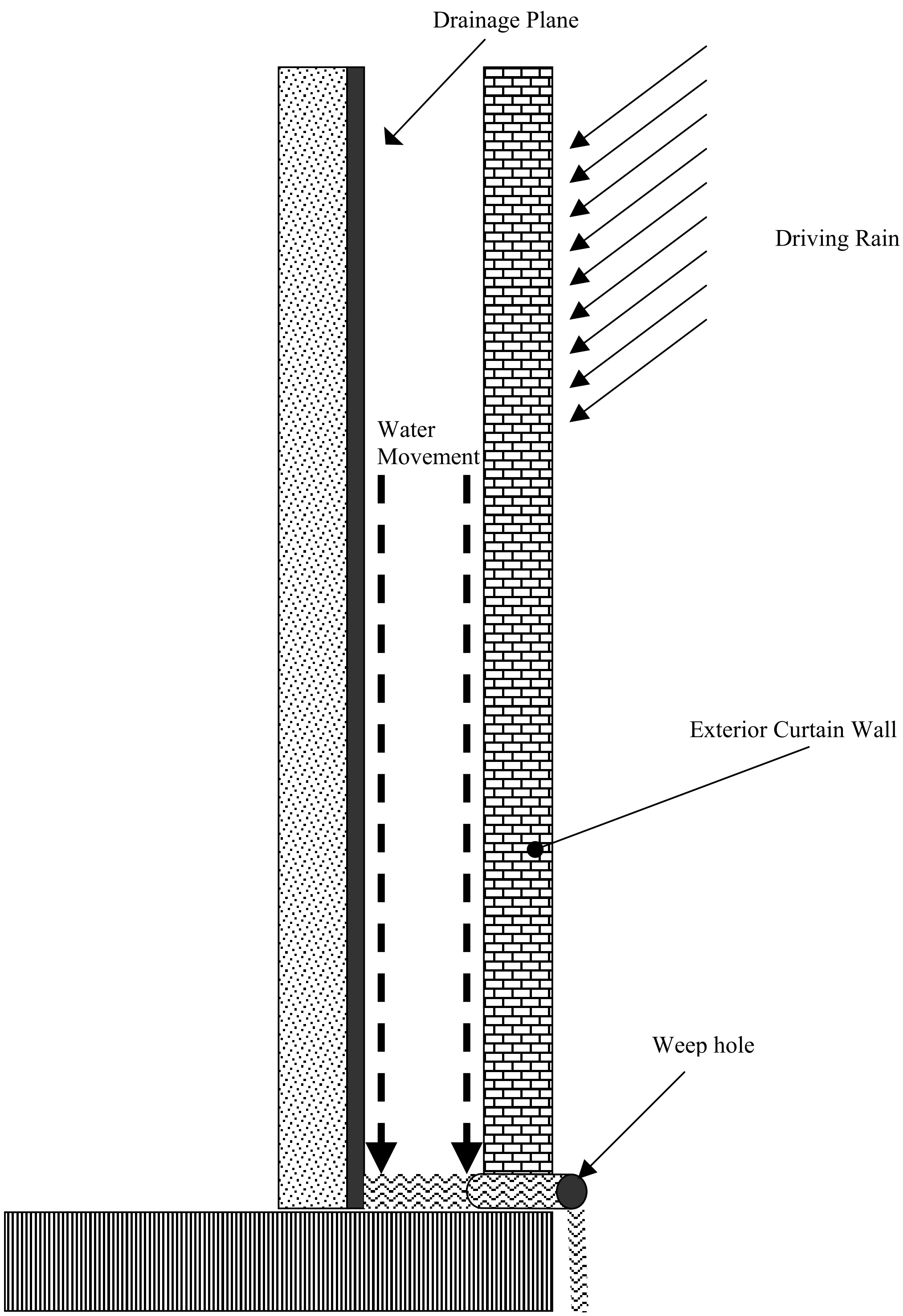
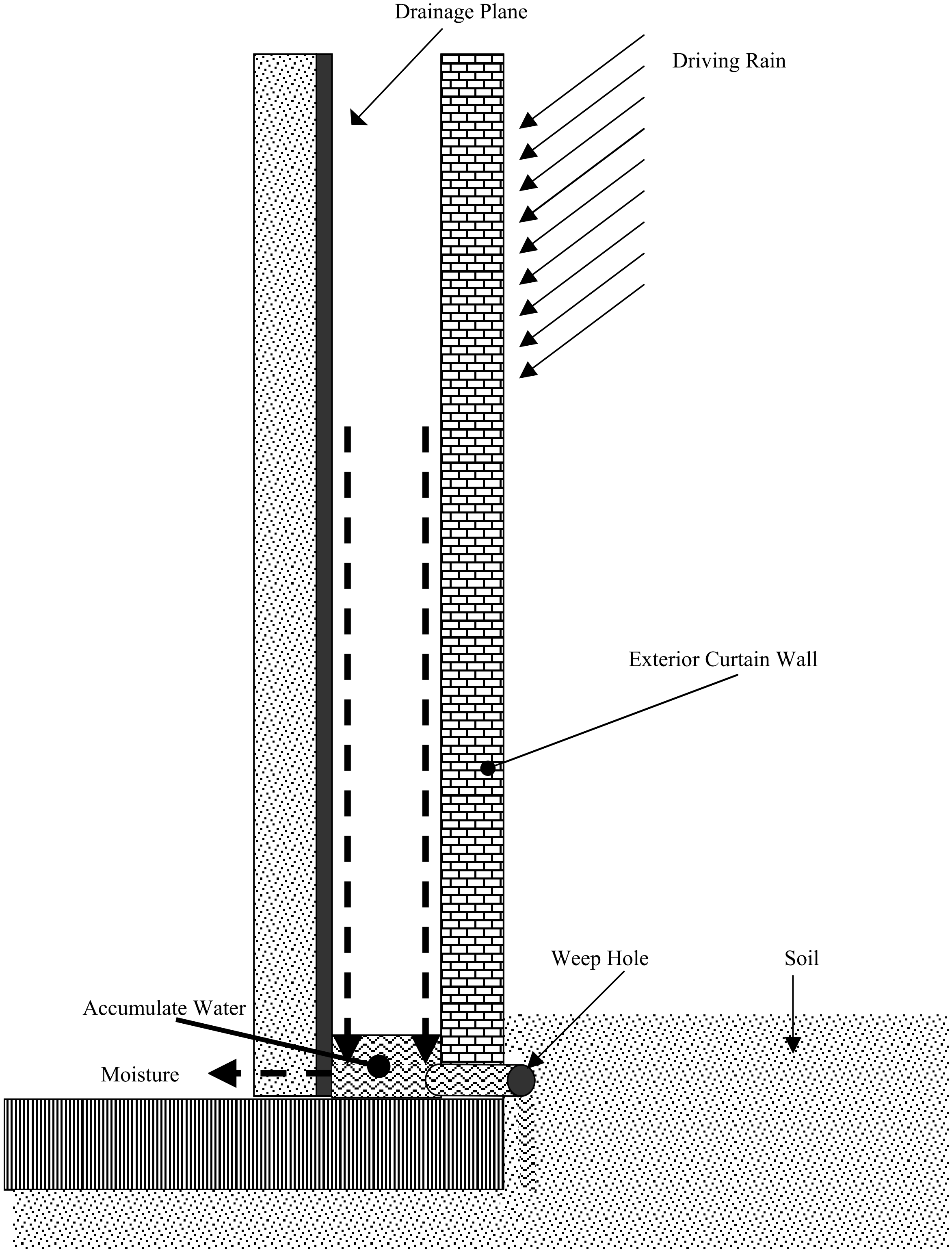


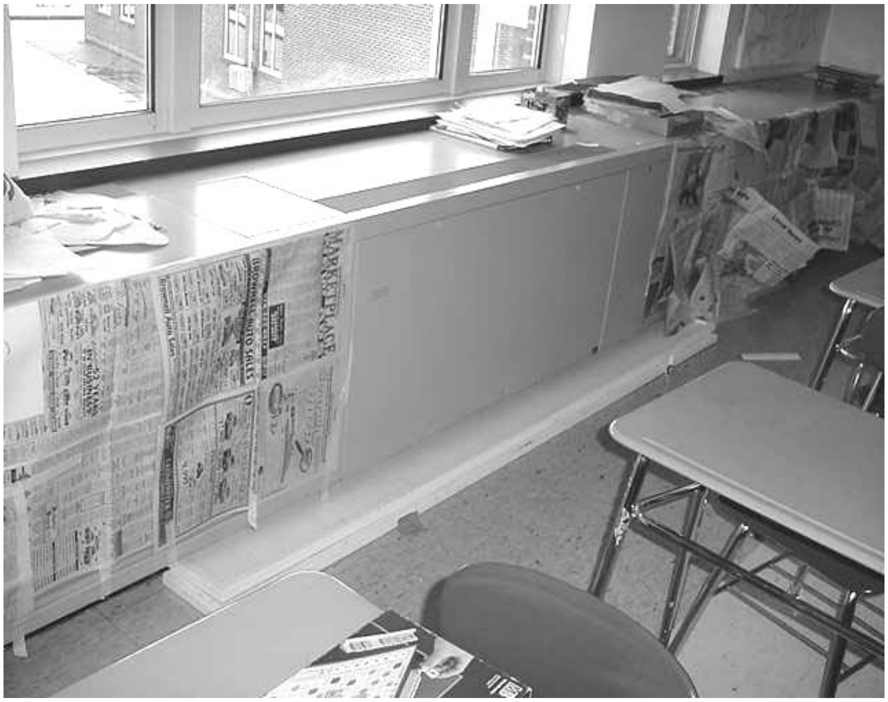
Figure 3
Weep Hole Blocked with Wick and Water Accumulation in the Drainage Plane



Picture 1

Univent, Note Tennis Balls on Chair

Picture 2



Univent Return Vent Blocked with Plank

Picture 3

Sidewalk outside Teacher's Lunch Room

Picture 4

Teacher's Lunch Room Exterior Wall/Sidewalk Junction

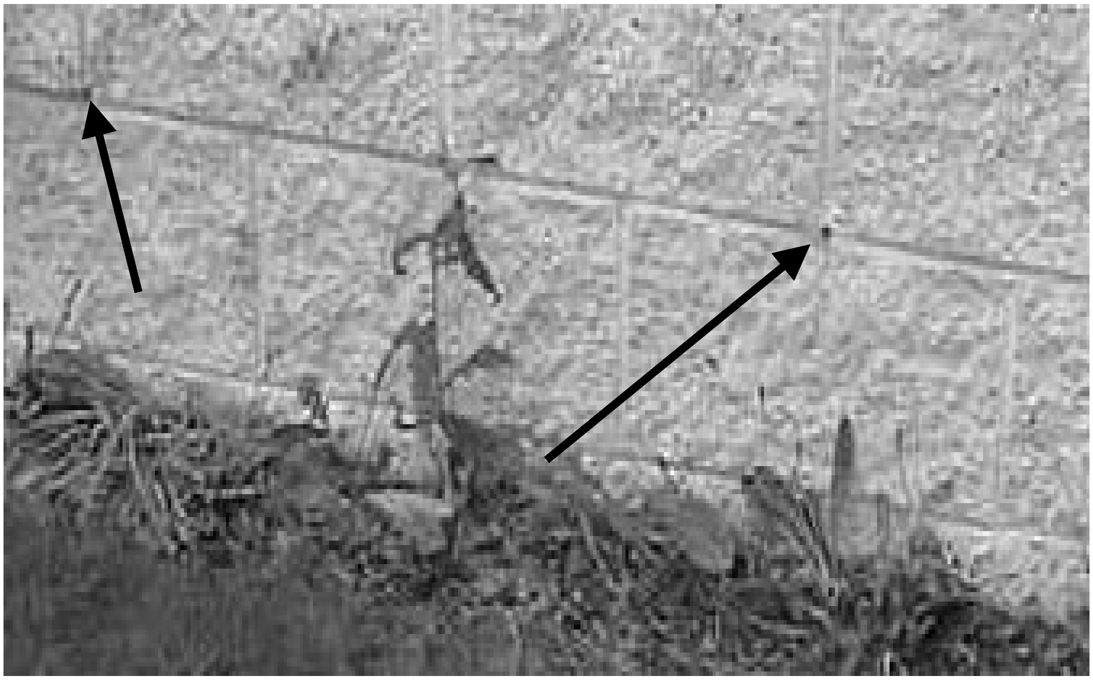
Picture 5

Teacher’s Lunch Room Exterior Wall Doorframe, Note Water Stain in Carpet

Picture 6

GMS Consists of A Traditional Red Brick Exterior Wall

Picture 7



Weep Holes Were Found Above Grade on the North Facing Exterior Wall of GMS

TABLE 1

Indoor Air Test Results: Gardner Middle School, Gardner, MA **June 23, 2003**

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Outside (Background)	406	76	55					
C307	617	78	57	1	Y	Y	Y	Window open, Door open
C302	580	78	57	2	Y	Y	Y	Door open
C301	489	77	57	0	Y	Y	Y	
Cafeteria	136	77	63	200+	Y	Y	Y	
Teacher's Room	496	74	62	0	Y	Y	Y	Carpet 15% saturated
Library	700	74	53	4	Y	Y	Y	
B101	875	74	58	1	Y	Y	Y	WD-WB, 25 computers
B103	980	73	57	0	Y	Y	Y	WD-WB, 28 computers

WD = water damage
CT = ceiling tile
WB = wallboard

ppm = parts per million parts of air

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 – 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

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Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Gym	504	76	60	0	Y	Y	Y	Space between exterior door and ground
Nurse's Office	831	76	47	2	N	Y	Y	
Conference Room	847	75	52	0	Y	Y	Y	Water cooler on carpet
C107	570	77	62	0	Y	Y	Y	Supply blocked by divider
6th Grade Teacher's Room	588	77	60	4	Y	Y	Y	WD-WB, glass plus cleaner, door open
7th Grade Teacher's Room	555	77	60	0	Y	Y	Y	Windows open; exhaust ventilation in restroom, but restroom did not have undercut doors; risograph
C207	736	78	62	13	Y	Y	Y	Door open
C213	838	78	60	8	Y	Y	Y	Door open, floor fan

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						Supply	Exhaust	
C212	516	78	55	1	Y	Y	Y	Windows open
C206	518	78	57	0	Y	Y	Y	Windows open
C213	451	77	54	0	Y	Y	Y	Door open
C208	450	77	55	0	Y	Y	Y	Wood plank blocking univent return vent; bleach/ammonia
C304	903	78	61	24	Y	Y	Y	
C103	568	75	63	1	Y	Y	Y	Door open, windows open, plants
C108	1059	76	65	60+	Y	Y	Y	Door open, windows open, plants
C109	877	77	63	28	Y	Y	Y	Door open
C104	915	76	62	50+	Y	Y	Y	Tennis balls on chair legs

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Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
C110	830	77	60	26	Y	Y	Y	Door open
C105	705	76	62	24	Y	Y	Y	Door open, plant
C111	966	77	62	25	Y	Y	Y	WD-WB, table blocking supply, floor fan
C106	637	76	61	0	Y	Y	Y	3 WD-CT
C112	571	76	62	0	Y	Y	Y	Door open, windows open, cleaner
C113	498	76	62	0	Y	Y	Y	Door open

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